

130N-1

## FASTENERS

AG 130-N

### UNIT OBJECTIVE

After completion of this unit, students will be able to identify fasteners used power, metal fabrication, and structures and understand the advantages and disadvantages of each. This knowledge will be demonstrated by completion of assignment sheets and a unit test with a minimum of 85 percent accuracy.

### SPECIFIC OBJECTIVES AND COMPETENCIES

After completion of this unit, the student should be able to:

1. Identify five samples of each of the various fasteners used in power, metal fabrication, and structures.
2. Demonstrate the ability to select the proper fasteners and hardware for specific jobs or for situations encountered in agricultural mechanics projects.

## TYPES AND USES OF FASTENERS

### A. Importance of Fasteners

1. They simplify the manufacture of machines and structures.
  - a. Fasteners reduce the need for large one-piece parts; it is normally much simpler to make less complex components and fasten them together.
2. They simplify repair of structures and equipment.
  - a. Individual component parts can simply and quickly be separated for inspection, repair, or replacement.
3. They provide safety.
  - a. Use of fasteners tends to assure that once an assembly is fastened together it will hold together. They can be installed to provide additional support or they can be the weak link that prevents dangerous major equipment failures (for example, shear pins on driveshafts and breakaway plowshares).

### B. General Types of Fasteners

1. Bolts, Nuts, and Washers
2. Screws
3. Keys
4. Studs
5. Pins
6. Rings
7. Rivets
8. Adhesives
9. Nails

### C. Specific Types and Uses of Fasteners

1. Bolts are threaded lengths of steel rod with heads on one end; they are used with a nut at the other end and sometimes with a washer as well.
  - a. American Standard (Hexagonal or Square-head) Bolts
    - 1) Most bolts have a hexagonal (6-sided) head although some older bolts have a square (4-sided) head.

- 2) Bolts are used with flat washers to fasten wood parts together and with or without lock washers to hold steel parts together.
- 3) Without a nut they are called cap screws and are used by screwing into a threaded hole.
- 4) Bolts are often selected by strength rating and/or chemical or temperature compatibility.

b. Carriage Bolts

- 1) Most have a round head with a square neck under the head although some have a flat, countersunk head; still others have finned or ribbed necks.
- 2) Carriage bolts are used to fasten wood parts or steel parts with square punched holes where a smooth finish is desired.

c. Plow Bolts (countersunk, square-neck carriage bolt)

- 1) These have flat, tapered heads that fit into countersunk holes in plowshares or other similar parts.
- 2) Plow bolts are used when it is necessary for the head to lie flush with the surface of the part, for example, attaching cultivator shovels to a standard and all components of a moldboard plowshare.

2. Nuts are flat, usually hexagonally-shaped steel pieces with internally cut threads that are screwed onto the threads of bolts.

a. Square nuts are also common; knurled round nuts are less common.

b. Jam Nuts

- 1) These are normally thinner than hex and square nuts and used to lock a standard nut into place by running up against the hex or square nut.
- 2) They are commonly used where vibration or cyclic loads may cause a bolt to unscrew.

c. Castellated and Slotted Nuts

- 1) These are hexagonal nuts with slots in the sides which resemble in appearance the walls of a castle that has been slotted for archers.

- 2) These are used when a cotter pin is placed through a hole in the bolt to secure the nut so it cannot come loose, for example, on wheel bearing spindles.

d. Self-locking Nuts

- 1) Once tightened, these nuts stay firmly in place.
- 2) They are commonly known as "elastic," prevailing-torque, or plastic-insert nuts.
- 3) They take the place of nuts with jam nuts and are generally more compact.

3. Washers

- a. Plain washers (flat washers) are steel disks with a hole in the center.

- 1) They are used to reduce the stress under a bolt or nut.
- 2) They spread the clamping force from the bolt over a larger area as would be needed with wood. They also span slots and oversize holes.

b. Lock Washers

- 1) Helical spring washers are made of tough, spring steel and normally installed under the nut (but they can also be used under the bolt, particularly cap screws).
  - a) The dimensions are specified like a plain washer.
  - b) They are used to prevent rotation of the nut.
- 2) Toothed ("shakeproof") lock washers give special holding power because the many sharp, heat-treated teeth to dig into the surfaces pressing against them.
  - a) They may have external, internal, or external/internal teeth.
  - b) They offer greater contact area to protect parts and provide a flat mating surface.

4. Screws are threaded lengths of steel rod with heads on one end.

## 130N-5

- a. Screw heads may be slotted for common screwdrivers, cross slotted for Phillips screwdrivers, square or hexagonally shaped for wrenches or other shapes described below.
  - b. Sheet metal screws are also known as thread-forming or tapping screws.
    - 1) They are used to attach light, thin parts made of sheet metal, soft metal castings, plywood, fiberglass, plastics, etc.
    - 2) The screw forms its own threads in the parts that it is screwed into.
  - c. Set screws are used to hold a collar, pulley, gear, etc. on a rotating shaft and in fractional horsepower applications; they prevent relative rotation between the two.
    - 1) They commonly have a hex (Allen) socket head but may also have a square or slotted head.
    - 2) A variety of point (tip) styles are available, ranging from cupped to flat to cone-shaped.
    - 3) Set screws are not an especially strong type of fastener and will normally score or raise a burr on the shaft which may make the part held to the shaft difficult to remove. Use of a flat or cavity on the shaft will prevent this.
  - d. Hex socket cap screws have a hole in the head of the screw made to fit a hex (Allen) wrench.
    - 1) They are used in recessed holes or in confined spaces where the small head size may be an advantage.
  - e. 12-point flange-head screws have external teeth around the heads to allow use of a small 12-point box-end wrench.
    - 1) These are used where small-diameter, high-strength screws are required, for example, on hydraulic motors.
5. Keys are square, rectangular, or semicircular-shaped steel pieces that are commonly used to hold a gear, pulley, or other part from rotating on a shaft.
- a. Both the shaft and the part to be held have a groove (keyway) cut into them.

## 130N-6

- b. A Woodruff (semi-circular) key extends deeper into the shaft and tends to eliminate "rocking" that may occur with square or rectangular keys.

### 6. Studs are steel rods with threads on both ends.

- a. One end is screwed into a part, while other parts are assembled over the stud and secured in place with a nut.

- 1) For example, studs are commonly used to attach the head of the engine to the engine block.

- b. Many studs have coarse ("interference") threads on one end and fine threads on the other.

- 1) The coarse threads go into the pilot hole and compress when screwed in to create the locking action.

### 7. Pins

- a. Spring pins (rollpins) are hollow cylinders of spring steel which are split lengthwise and chamfered at both ends.

- 1) They are made slightly oversize so they compress when driven or pressed into place.

- 2) They are frequently used to secure items to shafts for both thrust and rotary loads.

- b. Dowel pins are solid round steel pins used to assure that the fastened parts align exactly as they are designed.

- 1) The diameter of the dowel pin is slightly larger (0.0002" over) than that of the hole it is to be driven into.

- c. Quick-lock pins are square-shaped pins with a spring-like circular wire piece at one end which serves as an overcenter clip.

- 1) They are commonly found on 3-point hitches of tractors and implements.

### 8. Snap rings provide removable shoulders to accurately locate, retain, or lock components together against thrust loads.

- a. Internal snap rings fit inside grooves in holes.
- b. External snap rings fit inside grooves on shafts.

9. Rivets are soft metal pins with heads on one end.

- a. The common solid rivet is used primarily to hold two or more flat parallel parts together, for example, sheet metal parts and sickle sections on mower cutter bars.
- b. The blind (pop) rivet can be installed in a joint which is accessible from one side only, for example, sheet metal boxes or enclosures and for sheet metal patches.

1) Blind rivets are intended for light duty only.

10. Adhesives are glue-like materials which are spread on the two surfaces to be joined.

- a. Adhesives are used to join dissimilar materials or complex parts which would otherwise be difficult to join with conventional fasteners or welding techniques.
- b. Most adhesives are affected by the environment in which they are used and their strength may be adversely affected by temperature and exposure to moisture or other liquids.
- c. There are limitations to what materials may be effectively bonded with a specific adhesive, i.e., the "universal" adhesive does not exist.
- d. Epoxy

- 1) It is composed of two parts, a resin and a hardener, that must be mixed together.
- 2) It is excellent for general repairs but can be expensive.
- 3) Epoxy is commonly used on non-porous materials like metals and ceramics; it can also be used on woods and fabrics but they can as easily and cheaply be held together with white glue.

e. PVA (polyvinyl resin adhesive) Adhesives

- 1) A common example of PVA adhesives is white glue (such as Elmer's) that comes in a bottle ready to use.
- 2) White glue is suited to most interior woodworking and household repair jobs where high strength and dampness are not factors.

f. Resorcinal and Formaldehyde

- 1) Both adhesives are excellent for bonding wood to wood where structural strength is required.
- 2) Both require mixing, resorcinal with a resin and formaldehyde with water.
- 3) Formaldehyde is recommended for indoor use only due to its poor weather resistance qualities.
- 4) Resorcinal can be used in exterior applications due its superior resistance to water.

g. Silicone is used primarily as a sealing material in gaskets found in high temperature applications (up to 400 degrees F.). Room temperature vulcanizing (RTV) silicone is used for calking and making positive seals when used with conventional gaskets.

- 1) It is water and oil resistant.

h. Mastic

- 1) Synthetic latex mastic is water-based.
- 2) Rubber resin mastic is essentially synthetic rubbers in a solvent.
- 3) Both materials bond well to concrete, hardboard, asphalt, leathers, textiles, and ceramic tile.
- 4) Mastic is used for roof patching, asphalt sealing, and securing plywood panels to dry walls.

11. Nails

a. Nails are steel rods with a head on one end and usually pointed at the other end. They are used primarily to join wood together.

b. Common Nail

- 1) This is a general purpose construction nail suitable for framing of structures. It has a larger diameter than the same size box nail.

c. Box Nail

- 1) Box nails are used for end nailing and light household use.
- 2) The point is dulled to prevent splitting of wood.



## 130N-9

- 3) It has a smaller diameter than a common nail to help avoid splitting.

### d. Finishing Nail

- 1) This is a nail with a small head with a dimple in the center to allow for countersinking with a nail set.
- 2) Countersunk finishing nails are used in cabinetry or paneling.

### e. Duplex (double headed) Nail

- 1) A duplex nail has two heads on the shank.
- 2) It is used whenever the nail is to be removed, for example, in assembling concrete forms.

### f. Wire Staple

- 1) This is a "U" shaped nail.
- 2) It is used in fence construction and electrical wiring.

### h. Roofing Nail

- 1) This nail is used to secure shingles or roofing to the underlying structure; it has an oversized head.
- 2) They are normally available with either a spiral or helix-threaded shank for extra holding power.

### i. Flooring Nail

- 1) It is used to fasten hardwood floorboards.
- 2) It has a plain shank between the head and threads and can be installed with a floor nailing machine.

### Activity:

1. Test different methods of fastening 2 X 4s together with different fasteners, follow instructions on page 130N-17.
2. Using a press or any means available, break apart the test boards and record the results.

## SELECTION OF FASTENERS

## A. Specifications for Fasteners

## 1. Bolts

- a. Type (i.e., common, carriage, plow, etc.)
- b. Size

- 1) Diameter of the crest of the threads

## c. Length

- 1) Measured from the bottom of the bolt head to the end of the threads

## d. Threads

- 1) Specified by the number of threads per inch and by manufacturing tolerance of threads

- 2) Threads per Inch:

- a) UNC designated threads (coarse) are the most common in agricultural components.

- b) UNF (or SAE) designated threads (fine) are used in special conditions, for example, where parts being joined have thin walls.

- 3) Manufacturing tolerance (re fit) of threads.

- a) Thread class symbol such as 1A, 2A, etc.

## e. Grade (or property class) of bolts as delineated below:

Grade Marking*	Specification**	Material	Tensile Strength (psi)
No lines	SAE Grade 0	Low carbon steel	
No lines	SAE Grade 1	Low carbon steel	60,000
No lines	SAE Grade 2	Low carbon steel	74,000
3 lines	SAE Grade 5	Medium carbon steel, quenched and tempered	120,000
5 lines	SAE Grade 7	Medium carbon steel, quenched and tempered	133,000
6 lines	SAE Grade 8	Medium carbon alloy steel, quenched and tempered	150,000

\* Radial slashes on bolt head which are present on all bolts 1/4" or greater in diameter.

\*\* Grades 2 and 5 are most common in agricultural equipment. Grade 8 is common to engines, power transmission, and other high loading conditions.

#### f. Descriptive Symbols for Specifying Bolts

##### 1) Example:

1/2 - 20 UNC - 2A X 3

where,

1/2 = Bolt size (diameter) in inches

20 = Number of threads per inch

UN = Stands for Unified Screw Thread Standard

C = Coarse thread

2A = Thread class (fit) symbol

3 = Length of bolt (inches)

#### 2. Nuts

a. Type (hexagonal, square, castellated, jam, wing, cap)

b. Size

1) Diameter of the bolt to be used with the nut

c. Threads

1) Same as for bolts, i.e., UNC or UNF

#### 3. Washers

a. Type (plain, lock, etc.)

b. Actual inside diameter in inches

c. Bolt size that will fit through the inner hole in inches

1) Actual hole is approximately 1/32" larger than the bolt diameter.

d. Thickness of the washer in terms of the gauge of the metal that it is made from

#### 4. Screws (less than 1/4" in diameter)

## 130N-12

- a. Type (sheet metal, set, etc.)
- b. Size as specified below:

Screw Number	Diameter (in.)	Approximate Fraction
No. 2	0.086"	$>5/64"$
No. 3	0.099"	$>3/32"$
No. 4	0.112"	$>7/64"$
No. 5	0.125"	$1/8"$
No. 6	0.138"	$>9/64"$
No. 8	0.164"	$>5/32"$
No. 10	0.190"	$>3/16"$
No. 12	0.216"	$<7/32"$

### c. Length

- 1) Distance from the bottom of the screw head to the tip of the thread

### d. Number of Threads per Inch

### e. Head shape

- 1) Pan head
- 2) Flat head
- 3) Cross-recessed head (Phillips head)
- 4) Hex head
- 5) Allen socket head
- 6) Round head
- 7) Truss head
- 8) Oval head
- 9) Fillister head

## 5. Keys

- a. Type (square, Woodruff, etc.)

## 6. Studs

- a. Size in terms of the diameter
- b. Type of thread at each (stud and nut) end
- c. Thread length at each end of the stud
- d. Combined thread and "grip" length of the nut end

7. Pins

- a. Type (spring, dowel, etc.)
- b. Diameter of the pin
- c. Length of the pin

8. Rings

- a. Type (internal or external)
- b. Internal snap ring
  - 1) Inside bore (hole) diameter
  - 2) Groove diameter
  - 3) Ring width
- c. External snap ring
  - 1) Outside shaft diameter
  - 2) Groove diameter
  - 3) Ring width
- d. Spiral rings (internal and external)
- e. "C" and "D" rings (external)

9. Rivets

- a. Type (common, blind, etc.)
- b. Diameter
- c. Length

10. Adhesives

- a. Type (epoxy, PVA, silicone, mastic, etc.)
- b. Materials to be Joined
  - 1) Read the instructions for use of the adhesive to be sure that it is effective on the materials to be joined
  - 2) Request material safety data sheets.
- c. Environment
  - 1) Read the instructions for use of the adhesive to be sure that it is effective in the environment in which the joined materials will be placed

## d. Holding Power

1) Strength provided by the bond

e. Setting time

f. Curing time

## 11. Nails

a. Type (common, box, finishing, etc.)

b. Nail size or length of the nail as designated by the term "penny" and written as, for example, a "10d nail" which designates a 3-inch nail. (The penny abbreviation "d" derives from the denarius, an early Roman coin.)

1) The length of common nails (through a 10 penny nail) can be determined by dividing the penny by 4 and adding 1/2."

2) For example, the length of a 6 penny nail is:

$$a) 6/4 + 1/2 = 1-1/2" + 1/2" = 2 \text{ inches.}$$

<u>Size</u>	<u>Length in Inches</u>
2d	1
3d	1 1/4
4d	1 1/2
5d	1 3/4
6d	2
7d	2 1/4
8d	2 1/2
9d	2 3/4
10d	3
12d	3 1/4
16d	3 1/2
20d	4
30d	4 1/2
40d	5
50d	5 1/2
60d	6

## c. Nail Shank Treatment

1) Bright nails are untreated.

2) "Cement" coated nails are actually coated with a resin.

- 3) Chemically etched nails are designed to provide a rougher shank surface.
- 4) Annularly threaded nails have circular threads around the shank to give a better grip than a bright nail.
- 5) Helically (spirally) threaded nails have screwlike threads about the shank.
  - a) They hold better than bright nails and are commonly used to attach stair treads.
- 6) Helically barbed nails are deformed for greater withdrawal resistance.
- 7) Zinc coated nails are coated to provide stain and corrosion resistance but will also give greater gripping strength than bright nails.

d. Nail Point

- 1) A variety of nail points are manufactured in order to allow for faster penetration or to reduce wood splitting.
- 2) Some of the nail points available include:
  - a) Needle, pilot, chisel, wedge, blunt, long, etc.

e. Nail Head

- 1) Head selection is primarily based upon the materials being attached, i.e., the softer the material the larger the head.
- 2) Finishing nails have a small head with a dimple to allow for countersinking.
- 3) When building forms or temporary structures, double headed nails will allow for quicker disassembly.

References:

Cooper, Elmer L. (1997). AGRICULTURAL MECHANICS: FUNDAMENTALS AND APPLICATIONS, 3ed EDITION. Albany, NY: Delmar Publishers.

Editors of Reader's Digest. (1973). COMPLETE DO-IT-YOURSELF MANUAL (7th ed.). Pleasantville, NY: Reader's Digest Association.

Resources:

Baumeister, T., & Avallone, E. A. (1987). Marks' STANDARD HANDBOOK FOR MECHANICAL ENGINEERS (9th ed.). New York: McGraw-Hill.

Deere & Company. (1987). FASTENERS (3rd ed.) (Fundamentals of Service (FOS) Series). Available from: John Deere Technical Services, Dept. F, John Deere Road, Moline, IL 61265 (Available in Spanish)

Oberg, Erik, Jones, F. D., & Horton, H. L. (1990). MACHINERY'S HANDBOOK (23rd ed.). New York: Industrial Press.

Special Materials and Equipment:

Assortment of fasteners and associated hardware, Assortment of fasteners and materials to fasten together, 2x4s, wood screws, lag screws, carriage bolts, nails, etc.

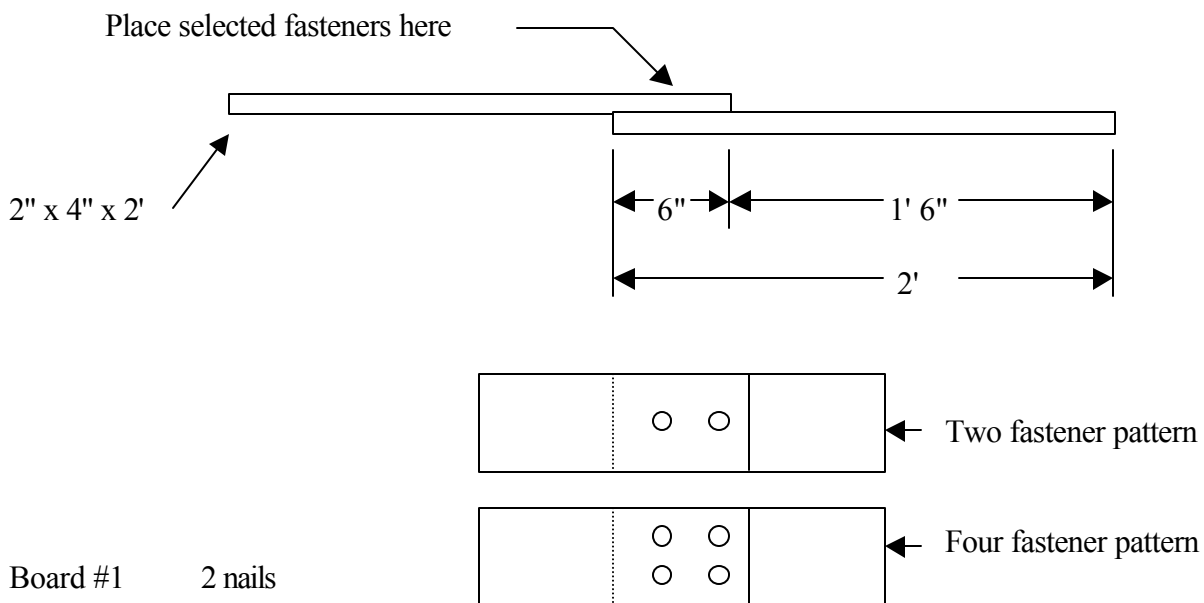


# Activity Sheet #1

## Testing Fasteners

Break students up into groups of two or three. Have each group make a different fastener test board using the directions and chart below. Some groups might do more than one test board

Fasten two 2 x 4s together with a 6 inch overlap using nails, wood screws, lag screw, or carriage bolts. On some boards glue will be required, be sure to check the chart number before fastening boards together.



Board #1	2 nails
Board #2	2 wood screws
Board #3	2 lag screws
Board #4	2 carriage bolts
Board #5	2 nails with glue
Board #6	2 wood screws with glue
Board #7	2 lag screws with glue
Board #8	2 carriage bolts with glue
Board #9	4 nails
Board #10	4 wood screws
Board #11	4 lag screws
Board #12	4 carriage bolts
Board #13	4 nails with glue
Board #14	4 screws with glue
Board #15	4 lag screws with glue
Board #16	4 carriage bolts with glue

Nails, use size 10d and clench  
 Wood Screws, use 2 1/4" wood screws  
 Lag Screws, use 1/4" x 2 1/4" lag screws  
 Carriage Bolts, use 1/4" x 3" carriage bolts  
 Glue, use Elmer's wood glue

**Note** – pre-drill holes for screws and bolts

130N-18

Name(s) \_\_\_\_\_

\_\_\_\_\_

Board # \_\_\_\_\_

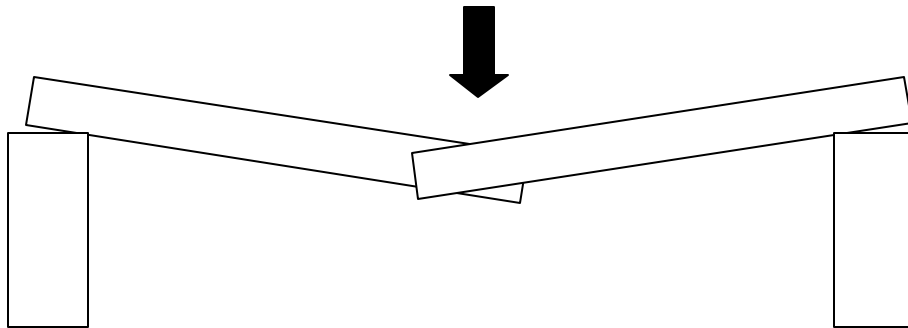
After each board has been tested and write down the results in the proper space and the findings at the bottom of the page.

What gave first? The wood or the fastener?

How many pounds of pressure did it take to break the connection?

How did the glue help the joints? Etc.

### Shear Strength Test



Results:

Board #1 \_\_\_\_\_  
Board #2 \_\_\_\_\_  
Board #3 \_\_\_\_\_  
Board #4 \_\_\_\_\_  
Board #5 \_\_\_\_\_  
Board #6 \_\_\_\_\_  
Board #7 \_\_\_\_\_  
Board #8 \_\_\_\_\_  
Board #9 \_\_\_\_\_  
Board #10 \_\_\_\_\_  
Board #11 \_\_\_\_\_  
Board #12 \_\_\_\_\_  
Board #13 \_\_\_\_\_  
Board #14 \_\_\_\_\_  
Board #15 \_\_\_\_\_  
Board #16 \_\_\_\_\_

Record the Findings:

Name \_\_\_\_\_

Date \_\_\_\_\_

Score \_\_\_\_\_

## FASTENERS, UNIT EXAM

Match the fastener on the right to the correct description on the left by placing the appropriate numbers in the blank.

- |  |                  |
|--|------------------|
| _____ 1. Round head with a square neck.                  | A. Set Screw     |
| _____ 2. Flat, tapered head with a square neck.          | B. Rivet         |
| _____ 3. Used where vibration may cause bolt to unscrew. | C. Duplex        |
| _____ 4. Used with a cotter pin                          | D. Wire Staple   |
| _____ 5. Steel disk with a hole in the center            | E. Plain Washer  |
| _____ 6. Used to hold on a pulley.                       | F. Carriage Bolt |
| _____ 7. Soft metal pins with heads on one end.          | G. Castle Nut    |
| _____ 8. Used to hold wire in fence construction         | H. Plow Bolts    |
| _____ 9. A nail with two heads.                          | I. Jam Nuts      |
| _____ 10. A nail with a small head.                      | J. Finish Nail   |

Answer the following questions with a short answer.

11. How long is a 9d nail? \_\_\_\_\_
12. What are "Cement" coated nails covered with? \_\_\_\_\_
13. What type of nail are used in cabinetry or paneling? \_\_\_\_\_
14. What type of adhesive is composed of a resin and a hardener? \_\_\_\_\_
15. They are commonly know as "elastic," preventing torque, or plastic-insert nuts.  
\_\_\_\_\_
16. Are horse shoe nails fasteners? Yes/no and why.

130N-20

Answer Sheet

1. F
2. H
3. I
4. G
5. E
6. A
7. B
8. D
9. C
10. J
11.  $2\frac{3}{4}$   $9/4 + 1/2 = 2\frac{3}{4}$
12. Resin
13. Finish Nails
14. Epoxy
15. Self Locking Nut
16. Yes, They hold the shoe on.

130N-21

## TYPES OF NAILS



8d Hinge



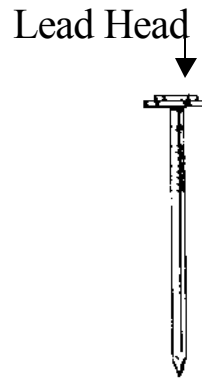
Plaster Board



Roofing



Shingle



Flooring



Box



Duplex



Wire Staple



Finishing



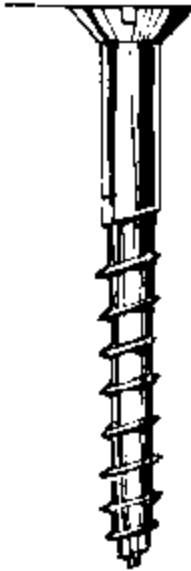
Common



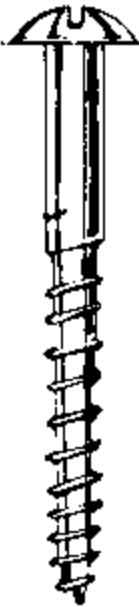
130N-22

## TYPES OF SCREWS

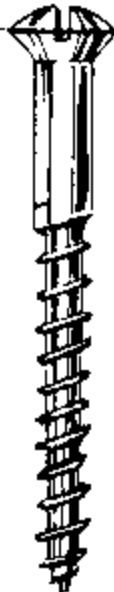
Flat Head



Round Head



Oval Head



Phillips

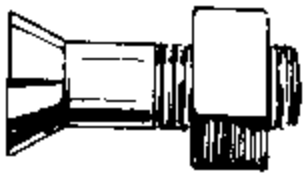


Lag



130N-23

## TYPES OF BOLTS



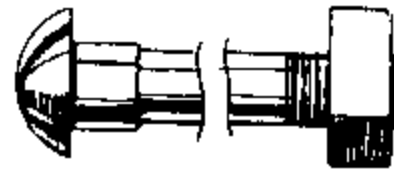
Plow



Round Head



Flat Head



Carriage



Machine



Expansion



Toggle



Eye Bolt



Hook Bolt



U Bolt



Turnbuckle

130N-24

## TYPES OF WASHERS



Plain Flat Washer



Star Lock Washer  
External



Star Lock Washer  
Internal - External



Common Lock Washer



Star Lock Washer  
Internal

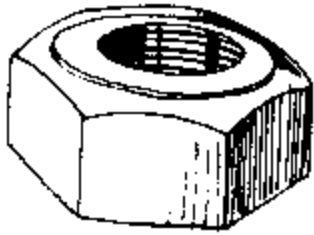


Star Lock Washer  
Countersunk

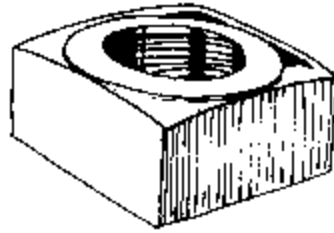


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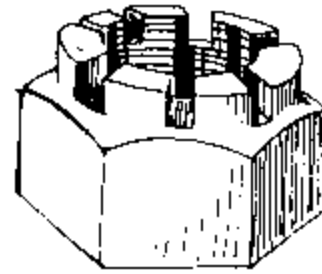
## TYPES OF NUTS



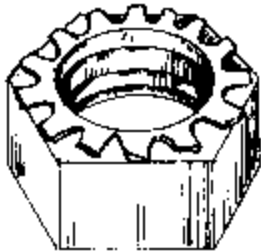
Hexagon



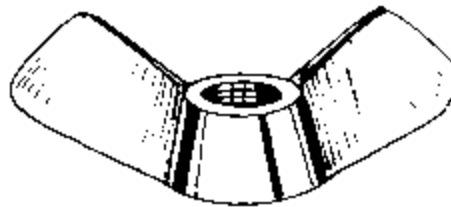
Square



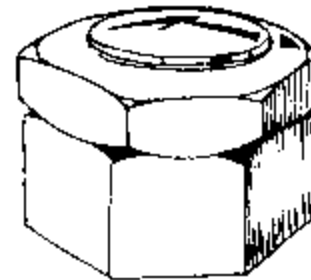
Castle or Slotted



Self-locking



Wing Nut



Jam or Lock Nut